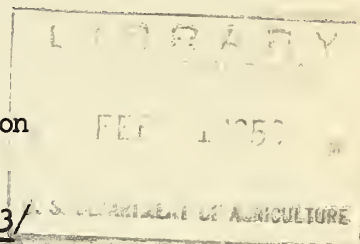


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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research ServiceX PHYSIOLOGIC RACES OF *PUCCINIA GRAMINIS* IN THE UNITED STATES
IN 1954, 1, 2/Plant Pest Control Branch
Field Crops Research Branch
and
Minnesota Agricultural Experiment Station(By E. C. Stakman, Donald M. Stewart,
E. B. Hayden, and Bill J. Roberts) 3/*Puccinia graminis tritici*

From 1,096 uredial collections of wheat stem rust made in the United States in 1954, 1,481 isolates were identified, comprising 25 races and recognizable biotypes or subraces (table 1). These include two groups designated the 17-29 group, which includes races 17, 37, and 29, and the 38-48 group. If the isolates in these two groups prove to be identical with races already listed, the number would be reduced to 23.

1/ Paper No. 3387, Scientific Journal Series, Minnesota Agricultural Experiment Station. A "Preliminary report on physiologic races of *Puccinia graminis* in the United States and Mexico in 1954" was issued in mimeographed form on November 15, 1954.

2/ For summaries for the years 1939 through 1942, see 522 and 522A to C in the former Bureau of Entomology and Plant Quarantine E-series; for 1943, 1945-49, and succeeding years, see unnumbered publications in the Physiologic Races series.

3/ Many collections were made by barberry-eradication personnel; a considerable number by members of the Field Crops Research Branch; and some by members of State agricultural experiment stations. Special acknowledgment for collections is made to Donald G. Fletcher, executive secretary of the Rust Prevention Association, Minneapolis, Minnesota. Ralph U. Cotter assisted in race identification at various times.

The most prevalent race of wheat stem rust in 1954 was 15B. It occurred in 65 percent of the collections and comprised 48 percent of the isolates (see fig. 1). Since this race is known to comprise a number of biotypes, additional differential varieties are being sought to distinguish between the biotypes more definitely than is possible with the present differential varieties. Race 15B was widely distributed except west of the Rocky Mountains, where it was found only in Washington and Oregon. It has not yet been found in California.

Race 15, which is more virulent on some varieties than the biotypes of 15B so far tried, was not very prevalent but was fairly widely distributed, having been isolated from collections made in Illinois, Kentucky, North Dakota, Ohio, Oregon, and Texas. This race was isolated also from aecial material from South Dakota.

The race 17-29 group comprised about 12 percent of the isolates. Of these, 5 percent were definitely race 29, and it is likely that most of the others were race 29 also. It has not yet been possible to test all of them at moderate temperatures, which is necessary to distinguish clearly between the races of this group. Race 29 was very prevalent in Mexico and was widely but irregularly distributed in the United States. It was common in the southeastern States and northward east of the Mississippi River. It was fairly prevalent in Texas, was not found at all in Oklahoma, Kansas, and Nebraska, and was found only rarely in the Dakotas and Minnesota. There is no apparent reason for this pattern of distribution. Further study is required.

Race 38 comprised about 12 percent of the isolates and was widely distributed. It has been necessary to designate some isolates as belonging

to a race 38-48 group. There appear to be biotypes which intergrade between the two races and whose infection type on some of the differential varieties is affected considerably by temperature. This group comprised about 5 percent of the isolates, with rather wide geographic distribution.

Race 48, which was found only in New York and Virginia, probably originated on barberry. Race 48A, which is clearly distinguishable from the other biotypes of this group, comprised about 4 percent of the isolates and was widely distributed. Race 48A can cause severe infection on Bowie and Travis wheats.

Race 56, with about 12 percent of the isolates, was widely distributed.

Race 11 was widely distributed but comprised only about 2 percent of the isolates. This race is potentially important, because some of its biotypes are exceptionally virulent on certain wheat varieties. It seems to be established in California, as it has been found there several years in succession. In 1954 it was also found in Washington, Oregon, and Idaho. East of the Rocky Mountains it occurred in South Dakota, Iowa, Illinois, Indiana, Michigan, Ohio, Kentucky, and Virginia. It was also in Florida, Mississippi, and Texas. Race 32, which can be distinguished from race 11 at moderate but not at high temperatures, comprised 0.5 percent of the isolates and was found in five States. Race 11 was isolated also from aecial material in Wisconsin, and race 32 from aecial material in Iowa.

Race 139, which threatened to become prevalent a few years ago, was isolated only from uredial material in Mississippi and Ohio and from aecial material in Virginia. Although it has not become prevalent, it still is persisting—probably in the uredial stage in the South and certainly by means of the aecial stage in Virginia.

A number of relatively rare races such as 61, 62, 95, and 122 were isolated from uredial material once each. Races 61 and 62 were isolated in Idaho, race 95 in West Virginia, and 122 in Pennsylvania--all probably originating on barberry. These races are not known to be dangerous, although the last three produce heavy infection on the durum wheats in the differential series and may possibly have especially high virulence for other durums. In any case, there is strong circumstantial evidence that these races are spreading considerable distances from barberry.

From 34 collections of aecial material, 45 isolates were obtained, comprising 21 races and biotypes--a different race or biotype in every 1.6 collections (table 2). This is an unusually high ratio, even for aecial collections, but it is possible that the sample was not adequate. Race 15B was isolated from aecial material from eight States: Colorado, Illinois, Iowa, Michigan, Minnesota, Pennsylvania, South Dakota, and Wisconsin. These results, with those given in several previous reports, are conclusive evidence that race 15B is now persisting both by means of barberry in the North and by uredia in the South.

Of the races isolated only from barberry, none are known to be especially dangerous--with the exception of race 57, which attacks Vernal emmer. Some of them, however, may prove to be virulent on new grain varieties or breeding materials, as was true in the case of races 49 and 139.

It is significant that the races that were common in the United States were also rather common in Guatemala and Mexico. From Guatemala, 55 collections were identified; and from Mexico, 172. Details on the results from these two countries are not given here, as they will probably be published in cooperation with the respective countries. A list of the races found in

each, however, follows: Guatemala, 11, 15B, 17-29 group, 29, 24A, 38-48 group, 56, 73A, 139; Mexico, 9, 11, 15, 15B, 17-29 group, 29, 38-48 group, 38, 48A, 49, 56, 62, 139. Race 48A was found in about 46 percent of the collections from Mexico and comprised 31 percent of the isolates. Race 29 occurred in almost 30 percent of the collections and comprised 20 percent of the isolates. It is almost certain that virtually all of those listed in the 17-29 group will prove to be one of the biotypes of race 29. If this is true, then race 29 will have occurred in approximately 50 percent of the collections and will comprise about 34 percent of the isolates. The next most prevalent race in Mexico was 15B, with 18.5 percent of the isolates.

Shifts in the prevalence of physiologic races in regions or countries from which spores may be blown into the United States are of extreme importance. As one example, some isolates of races 29 and 48A, which increased rapidly in prevalence in Mexico in the early spring of 1954, can attack Selkirk, a new hard red spring-wheat variety released in Canada and the United States in 1955. Both of these races subsequently became rather prevalent in the United States.

Race 139 is persisting in Guatemala, Mexico, and the United States, although apparently in small amounts only.

Systematic search has been made for additional differential varieties. They are urgently needed for two principal reasons: 1. To distinguish more clearly between biotypes within certain races; 2. To distinguish between certain races that appear alike on the present differential varieties at the relatively high temperatures that are likely to prevail during the summer, when the race survey must be made. The following varieties were tested against a large number of isolates collected during the 1954 survey:

<u>Variety or Line</u>	<u>C.I.Number</u>	<u>Source of Seed</u>
Willet	13099	Minnesota Agricultural Experiment Station
Selkirk	13100	
Newthatch	12318	
Frontana x (K58-Newthatch)	13155	
Kentana 52	13085	Oficina de Estudios Especiales (Mexican Department of Agriculture in cooperation with The Rockefeller Foundation)
Gabo 54	-	
Yaqui 53Y (Y50 x E-T 2156)	-	
Mayo 54 (E-T) Mayo	-	
Yaktana 53 (Y50-Kt48)	-	
Kenya Farmer (Kenya 338 A.C.2E.2)	12880	Cereal Crops Section, Field Crops Research Branch, ARS, U. S. Department of Agriculture
C.I. 3255 Durum	3255	
Bowie	-	Texas Agricultural Experiment Station

Of these, Bowie and Travis proved especially useful. Both of them are susceptible to most of the isolates of 29 and 48A, against which they were tested in 1954 and during the winter and spring of 1955. The presence of these races in mixtures with 15B is sometimes difficult to determine on the regular differential varieties. Both Bowie and Travis are extremely useful in detecting them, as they are resistant to 15B and susceptible to both 29 and 48A.

Puccinia graminis avenae

A total of 692 isolates of oat stem rust, comprising 9 races, were identified from 508 collections (table 3). Of these, the following were most prevalent: race 7, 8, 2, and 7A. Race 7 comprised 58 percent of the isolates; race 8, 17 percent; race 2, 13 percent; and race 7A about 9 percent (fig. 2). The other races were found only occasionally. Race 6, a dangerous race, was isolated twice each from Maine and New Hampshire, and

three times from Pennsylvania. The inoculum undoubtedly originated on barberry.

Race 6 was isolated also from aecial material from Illinois, and the closely related race 13 was found in Pennsylvania.

Only 11 aecial collections were identified (table 4). They included races 2, 6, 7, and 7A. The appearance of race 7A on barberry in Iowa, Minnesota, and Pennsylvania, and especially of race 6 in Illinois, is noteworthy.

Eleven varieties or lines of oats were added on a trial basis to the three regular differential varieties in all of the race identifications made in 1954. They are listed below with their known behavior toward those isolates of stem rust with which they have been inoculated.

Rodney (R.L.2123). This variety has the "Canadian" or Hajira type of resistance to all known races except 7A at moderate temperatures (70 to 80°F). At low or moderate temperatures, Rodney is a good differential for 7 and 7A, but at high temperatures the infection type produced by race 7 approaches that produced by 7A.

Clinton x Ukraine (C.I.6537) appears to have a resistance equivalent to that of Minrus and Rodney combined.

New Garry (R.L.16921) apparently has a resistance equivalent to that of Richland and Rodney combined.

Minnesota '53 Ag.307 and 354 are selections from the cross [Landhafer x (Mindó x Hajira-Joanette) x Andrew] and appear to have a resistance equivalent to that of Minrus, Richland, and Rodney combined.

Minnesota Selection II-46-7 [(Bond-Rainbow x Hajira-Joanette) x Landhafer] reacts the same as Rodney.

Minnesota Selection II-47-11 [Landhafer x (Mindó x Hajira-Joanette)] has a resistance equivalent to that of Minrus and Rodney combined.

Saia (C.I.4639) is susceptible to some isolates of oat stem rust in South America but has been resistant in the United States. Although no collections or isolates encountered in the survey caused heavy infection on Saia, its reaction ranged from highly resistant to mesothetic.

Clinton² x Arkansas 674 (C.I.6643) has a resistance comparable to that of Minrus in tests made at St. Paul, but some selections from this cross have been used as possible differentials for some isolates of race 7.

Nortex (C.I. 2382) and New Nortex (C.I.3422) were added as possible differentials for race 14.

Of these varieties, Rodney and Clinton x Ukraine have proved to be satisfactory differentials for distinguishing between races 7 and 7A at temperatures up to about 80°F.

Table 1.-Physiologic races of *Puccinia graminis tritici* isolated from uredial collections in the United States in 1954

State	Race and number of times isolated																										Total number of	
	35-																										Iso- : 'Collec-	
	1	10	11	15	15B	29	29	19	32	34	38	48	48	48A	56	59	59A	59B	59C	61	62	95	122	125	139	ates	Races	tions
Alabama	-	-	-	-	8	11	-	-	-	-	1	2	-	4	-	-	-	-	-	-	-	-	-	-	-	26	5	17
Arkansas	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
California	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	3
Colorado	-	-	-	-	15	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	21	2	16
Florida	-	-	-	-	9	3	1	1	-	-	8	-	-	-	1	-	-	-	-	-	-	-	-	-	-	24	7	17
Georgia	-	-	-	-	4	4	1	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	5	12
Idaho	-	-	8	-	-	1	-	-	1	-	4	5	-	1	4	-	-	-	-	1	1	-	-	-	-	27	10	24
Illinois	1	-	1	1	34	3	3	8	2	-	3	4	-	3	16	-	-	-	-	-	-	-	-	-	-	75	10	46
Indiana	-	-	3	-	18	5	5	10	-	-	17	8	-	2	6	-	-	-	-	-	-	-	-	-	-	71	9	34
Iowa	-	-	1	-	49	2	1	1	-	1	6	1	-	1	14	-	-	-	-	-	-	-	-	-	-	69	7	51
Kansas	-	-	1	-	28	8	-	-	-	-	16	9	-	3	2	-	-	-	-	-	-	-	-	-	-	61	9	33
Kentucky	-	-	5	1	9	8	-	-	-	-	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	3	2	3
Louisiana	-	-	-	-	-	-	-	-	-	-	17	12	-	9	12	-	-	-	-	-	-	-	-	-	-	98	8	55
Michigan	-	-	1	-	37	4	1	6	-	-	8	4	-	6	8	-	-	-	-	-	-	-	-	-	-	86	3	77
Minnesota	-	-	-	-	76	11	7	-	-	-	8	4	-	2	3	-	-	-	-	-	-	-	-	-	-	47	8	31
Mississippi	-	-	1	-	6	11	3	2	-	-	2	1	-	2	3	-	-	-	-	-	-	-	-	-	-	54	7	46
Missouri	-	-	-	-	41	3	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	49	2	46
Montana	-	-	-	-	46	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	50	2	42
Nebraska	-	-	-	-	41	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	14	6	10
New York	-	-	-	-	6	1	1	-	-	-	3	-	-	1	1	2	-	-	-	-	-	-	-	-	-	20	6	15
North Carolina	-	-	-	-	2	2	3	-	-	-	10	-	-	2	1	-	-	-	-	-	-	-	-	-	-	105	5	99
North Dakota	-	-	-	1	1	15	10	1	-	-	23	7	-	2	12	-	-	1	-	-	-	-	-	-	-	84	12	53
Ohio	-	-	1	1	1	10	-	-	1	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	14	2	11
Oklahoma	-	-	3	-	1	3	-	-	1	-	-	3	-	1	-	-	-	-	-	-	-	-	-	-	-	14	8	11
Oregon	1	-	-	-	11	4	3	1	-	-	18	8	-	1	15	4	5	3	3	-	-	-	1	-	-	14	7	13
Pennsylvania	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1	1
South Carolina	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	-	-	-	-	-	-	-	-	-	-	57	7	51
South Dakota	-	-	1	-	47	1	1	6	-	-	8	5	-	1	2	-	-	-	-	-	-	-	-	-	-	28	7	18
Tennessee	-	-	-	-	2	4	3	-	-	-	9	1	-	9	14	1	-	-	-	-	-	-	-	-	-	111	11	91
Texas	-	-	1	1	59	12	3	-	-	-	4	2	2	2	6	9	7	-	1	-	-	-	-	-	-	46	13	32
Virginia	-	-	1	-	2	5	2	1	-	-	4	2	4	1	-	-	-	-	-	-	-	-	-	-	-	8	6	8
Washington	-	-	1	-	1	1	-	-	-	-	3	2	-	1	1	1	2	2	-	-	-	-	-	-	-	12	8	9
West Virginia	-	-	-	-	1	1	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	49	6	31
Wisconsin	-	-	-	-	28	-	2	-	-	-	7	1	-	3	8	-	-	-	-	-	-	-	-	-	-	12	8	9
Wyoming	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	1	7
Totals	2	1	33	6	713	96	75	3	7	1	177	76	5	58	177	17	14	7	5	1	1	1	1	2	2	1,481	25	1,096
Percentage of isolates	0.14	0.07	2.20	0.40	48.14	6.48	5.06	0.50	0.07	11.95	5.13	0.33	0.33	3.91	11.95	1.14	0.94	0.50	0.33	0.07	0.07	0.07	0.07	0.14	0.14	0.14	0.14	0.14
Percentage of collections	0.18	0.09	3.01	0.54	65.05	8.76	6.84	0.27	0.64	0.09	16.15	6.93	0.45	5.29	16.15	1.55	1.27	0.63	0.45	0.09	0.09	0.09	0.09	0.18	0.18	0.18	0.18	0.18

Table 2.-Physiologic races of Puccinia graminis tritici isolated from aecial collections in the United States in 1954

State	Race and number of times isolated																Total number of -							
	11	15	15B	17- 29	29	32	33	38	38- 48	47	48A	56	57	59	59A	59B	59C	98	102	111	139	Iso- lates	Races	Collec- tions
Colorado	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	2
Illinois	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	3	2
Iowa	-	-	1	2	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	7	5	6
Kentucky	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	1	1
Michigan	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
Minnesota	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	3	3	2
New York	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	2	2	1
Pennsylvania	-	-	4	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	5	2	4
South Dakota	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	1
Virginia	-	-	-	-	-	-	-	-	1	-	1	-	1	1	1	-	-	-	-	-	1	7	7	6
Washington	-	-	-	-	-	-	1	1	1	1	-	1	-	-	-	1	-	-	-	-	-	6	6	3
Wisconsin	1	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	6	5	5
Totals	1	1	13	4	1	1	1	2	2	1	2	3	1	2	1	2	1	2	2	1	1	45	21	34
Percentage of isolates	2.2	2.2	28.9	8.9	2.2	2.2	2.2	4.4	4.4	2.2	4.4	6.7	2.2	4.4	2.2	4.4	2.2	4.4	4.4	2.2	2.2			

Table 3.--Physiologic races of Puccinia graminis avenae isolated from uredial collections in the United States in 1954

State	Race and number of times isolated										Total number of --		
	2	5	6	7	7A	8	10	12	13	Iso- lates	Races	Collec- tions	
Alabama	8	1	-	2	-	-	-	-	-	11	3	11	
Arkansas	1	-	-	-	-	1	-	-	-	2	2	1	
California	1	-	-	-	-	-	-	-	-	1	1	1	
Colorado	-	-	-	4	-	-	-	-	-	4	1	4	
Florida	1	-	-	3	-	1	-	-	-	5	3	3	
Georgia	1	-	-	7	-	6	-	-	-	14	3	10	
Idaho	2	-	-	-	-	1	-	-	-	3	2	3	
Illinois	3	-	-	31	7	3	-	1	-	45	5	34	
Indiana	-	1	-	4	1	-	-	-	-	6	3	6	
Iowa	6	-	-	38	4	5	-	-	-	53	4	43	
Kansas	3	-	-	9	1	1	-	-	-	14	4	11	
Kentucky	1	-	-	1	-	-	-	-	-	2	2	2	
Louisiana	4	-	-	-	-	1	-	-	-	5	2	4	
Maine	-	-	2	3	-	2	-	-	-	7	3	4	
Michigan	9	-	-	44	5	14	-	-	-	72	4	49	
Minnesota	3	-	-	33	6	13	-	-	-	55	4	39	
Mississippi	7	-	-	2	-	-	-	-	-	9	2	8	
Missouri	1	-	-	10	2	5	-	-	-	18	4	15	
Montana	8	1	-	18	4	8	-	-	-	39	5	21	
Nebraska	2	-	-	15	2	4	-	-	-	23	4	15	
New Hampshire	-	-	2	1	-	1	-	-	-	4	3	2	
New York	1	-	-	15	2	1	-	-	-	19	4	16	
North Dakota	2	-	-	17	6	5	-	-	-	30	4	21	
North Carolina	-	-	-	3	1	-	-	-	-	4	2	3	
Ohio	-	-	-	31	6	4	-	-	-	41	3	35	
Oklahoma	1	-	-	2	-	1	-	-	-	4	3	2	
Oregon	3	-	-	-	-	-	-	-	-	3	1	3	
Pennsylvania	-	-	3	14	5	6	-	-	1	29	5	26	
South Carolina	1	-	-	1	-	-	-	-	-	2	2	1	
South Dakota	1	-	-	24	4	4	-	-	-	33	4	25	
Tennessee	1	-	-	1	-	-	-	-	-	2	2	2	
Texas	11	1	-	22	1	6	-	-	-	41	5	26	
Virginia	3	-	-	1	1	2	-	-	-	7	4	4	
West Virginia	1	-	-	1	-	-	-	-	-	2	2	1	
Wisconsin	6	-	-	44	6	24	3	-	-	83	5	57	
Totals	92	4	7	401	64	119	3	1	1	692	9	508	
Percentage of isolates	13.3	0.6	1.0	58.0	9.2	17.3	0.4	0.1	0.1				
Percentage of collections	18.1	0.8	1.4	78.9	12.6	23.4	0.6	0.2	0.2				

Table 4. - Physiologic races of Puccinia graminis avenae isolated from aecial collections in the United States in 1954

State	:Race and number of times :				: Total number of --		
	: isolated :				: Iso- : : Collec-		
					: lates : Races : tions		
	: 2	6	7	7A	: lates	: Races	: tions
Illinois	-	1	1	-	2	2	2
Iowa	-	-	-	1	1	1	1
Minnesota	-	-	2	1	3	2	2
New York	-	-	2	-	2	1	2
Pennsylvania	-	-	-	1	1	1	1
Virginia	3	-	-	-	3	1	3
Totals	3	1	5	3	12	4	11
Percentage of isolates	25.0	8.3	41.7	25.0			

Relative prevalence of Puccinia graminis tritici
race 15B in the United States, 1950 - 1954

(Uredial collections)

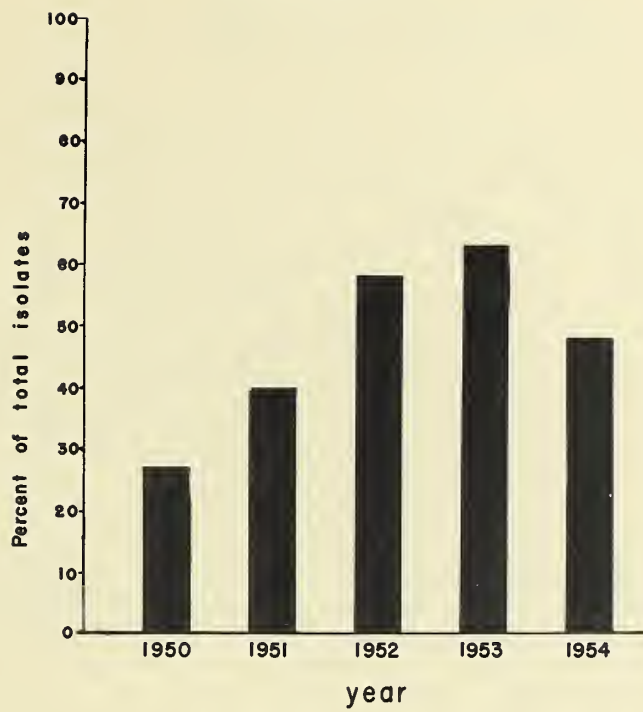


Figure 1

Puccinia graminis avenae
Prevalence 1939-1954

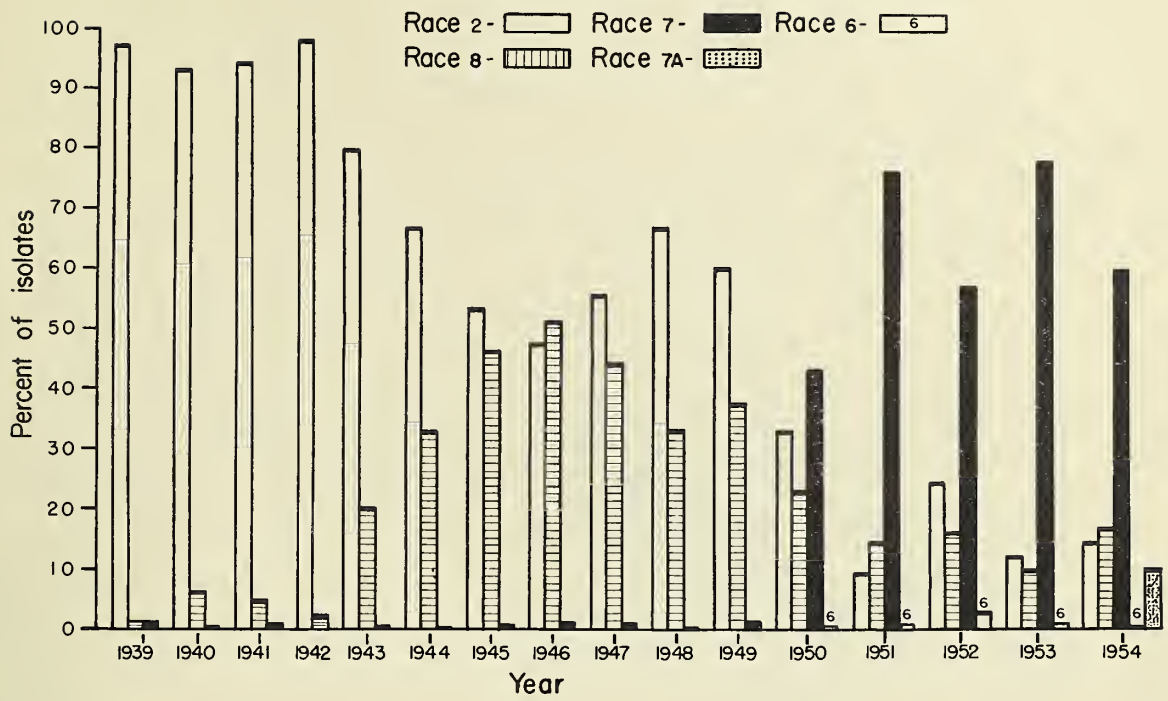


Figure 2

